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FABRICATION OF A UNMANNED AIR VEHICLE WING FOR BETTER ENDURANCE

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ABSTRACT

It's the trend of Unmanned Air Vehicles, where most of the surveillance work is carried out where in replacement of human power especially in enemy tracking. In recent trend UAVs are playing a major role in the national and international status in both civil and military purposes like surveillance, agriculture, medicine etc., The main objective is to design and fabricate an UAV for improved endurance. The Endurance depends on the power and the aerodynamic performance. Here for the improved aerodynamic efficiency the optimized airfoil is chosen. For better performance the lithium polymer battery is chosen. The improved endurance is calculated through computational and experimental analysis. And results are Compared and validated.

KEYWORDS: UAV, Fabrication & Aerodynamic

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Original Article

1. INTRODUCTION

One of the interesting aspects of flying vehicles is its design mimic the performance of the natural birds. Here the main challenge comes in the design, fabrication and integration of the unmanned air vehicles. Controlling the directional stability and performance of UAVs is also a typical task to be performed. Endurance, hovering, maneuvering and mission goal effectiveness are to be performed for better efficiency. To meet the design objective of the unmanned air vehicle computational analysis is carried out for the design with referred software's [1]. For the fabrication of the unmanned air vehicle, triangular wing is chosen especially roll and yaw stability [2]. The model provides effective maneurable and stability conditions. The aerodynamic and structural analysis is carried out using the optimized design criteria [3]. Further the optimized design will be fabricated with desired specifications and finally obtaining the results which are more efficient than the conventional model.

2. METHODOLOGY

2.1. Sources (XFLR5 Software's)

XFLR5 is an examination instrument for airfoils, wings and planes working at low Reynolds Number. It incorporates: XFoil's Direct and Inverse examination abilities and Wing plan examination in view of the Lifting line hypothesis and the VortexLattice Method. XFLR5 is outfitted with many devices that will prove to be useful at whatever point you will to investigate the segments and make fine changes. Thus, other than the regular zoom controls, it is conceivable to include a foundation picture. This can demonstrate exceptionally helpful on the off chance that you need to make a thought regarding how a specific wing, for instance, will look joined to the fundamental body. Adding a network to the present view and altering it is additionally conceivable with only two or three ticks. Thwart standardization, fare, duplication and different summons are to be found in the committed menu

of the application. XFLR5 is programming that empowers 2D and 3D streamlined investigation of bodies and bearing territories, independently or mutually. The product makes investigation for little Reynolds numbers. The most recent variant has executed five applications: a direct 2D examination and plan, a 3D investigation and configuration (wing, fuselage, air ship), two approaches to outline and look at 2D, outline a 2D QDES and MDES. As indicated by XFLR5 manual (Guidelines for XFLR5, 2011), the means in figure 3 ought to be considered when creating polar outlines suitable to the information.

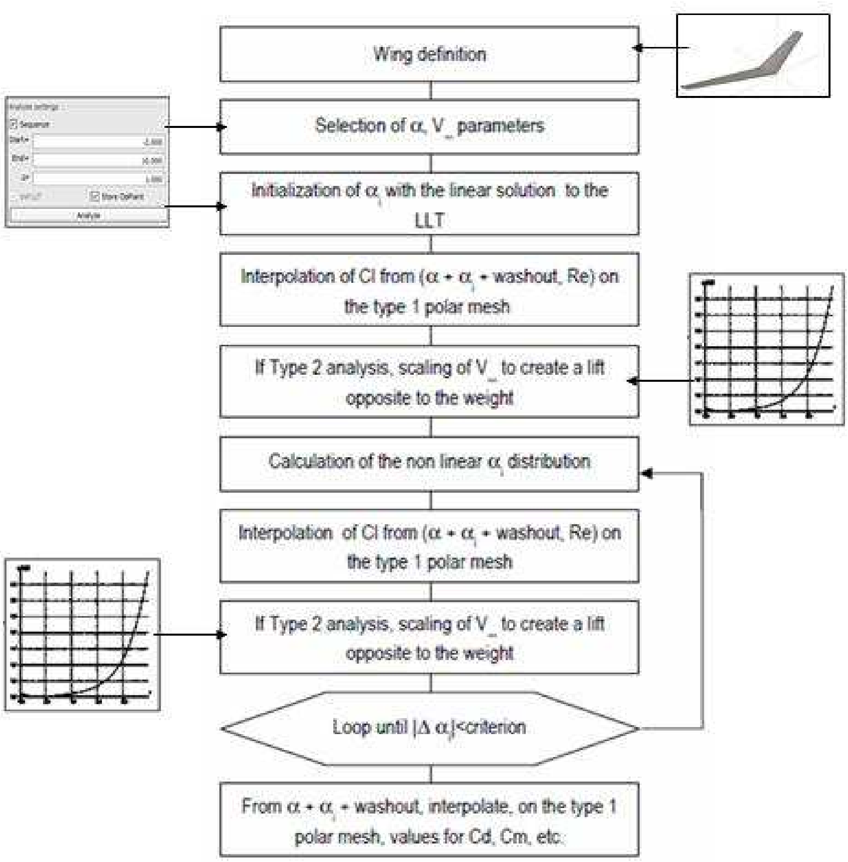

Figure 1: Representation of the Polar Diagram

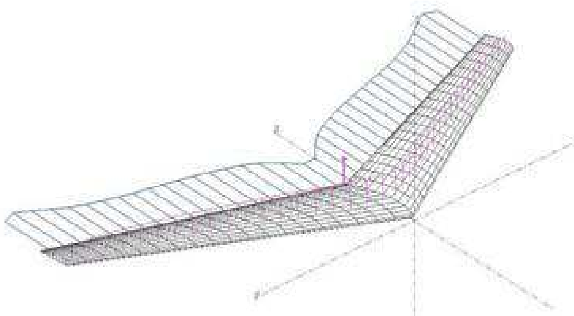

Figure 2: Lifting and Drag Diagram
(72 km/h and 5^0 Incidence)

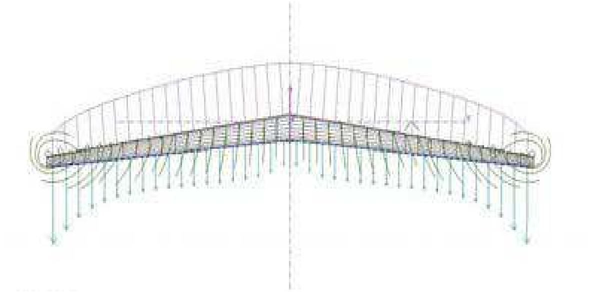

Figure 3: Lifting an Induce Drag Diagram
(72 km /h and 12^0 Incidence)

2.2. Components and Materials

Table 1

S. No	Material	Dimensions
1	Foam Material	Dimensions: Length= 1m, Breadth = 0.5 m
2	Specialty Foams	UFP special maerial
3	Motors	935Kv, 12V supply where it will have 935*12 Revolutions.
4	Lipo Battery	4.35V
5	Propeller	Dia= 9" (22.86 cm) ; Pitch=4.7" (11.93 cm) ;Thrust=(850-900) gms
6	Transmitter	FS-T6 ; RF Range 2.40-2.48GHz; Bandwidth =500Hz ;Power 12V DC (1.5AA*8)
7	Servos	Two elevon servos

3. FLYING WING DESIGN

Design approach was taken from the flying creature that is quetzalcotlusnorthopi which is even known as flying lizard, a family of advanced toothless pterosaurs with unusually long, stiffened necks individual with a wingspan as large as 15.9 m (52 ft), choosing the middle of three extrapolations from the proportions of other pterosaurs that gave an estimate of 11 m, 15.5 m, and 21 m, respectively(36 ft, 50.85 ft, 68.9 ft A majority of estimates published since the 2000s have been substantially higher, around 200–250 kg. Aero environment's specialized portfolio of UAS provide critical intelligence and high precision strike capabilities that can mean the difference between failure and certain success

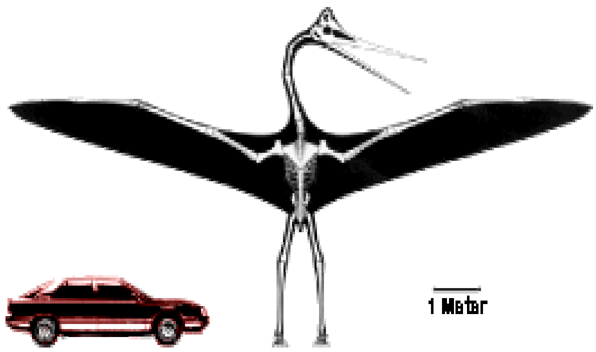

Figure 4: Quetzalcoatlusnorthropi Bird

The flow of mass per unit time is produced by the wings grabbing the air and throwing it down. Earlier it was stated that the cross sectional area of air A grabbed by the wings is about ½ b^2. Thus

$$\frac{dm}{dt} = \rho * \frac{dv}{dt}$$
$$\frac{dm}{dt} = \rho * A * \frac{dx}{dt}$$
$$\frac{dm}{dt} = \rho * A * v$$
$$\frac{dm}{dt} = \rho(\frac{1}{2}b^2)v$$

Substituting this into our main lift equation gives:

$$w = v * \rho(\frac{1}{2}b^2)v$$

Where W is the weight of the airplane, *v* is the speed of the air being thrown down, ρ is the density of the air, v is the relative speed of the plane through the air, and ½ b^2 is the effective area A surrounding the plane affected by the wings as they cut through the air.

3.1. Power Required for Lift

As the plane flies through the air, the wings are converting some of the airplanes forward thrust to throwing air down so as to lift the airplane up. This process of throwing the air down requires energy; energy that the airplane gives to the air. The kinetic energy of a moving object is calculate as

$$E = \frac{1}{2}mv^2$$

Since the airplane is continuously giving this energy to the air it is more appropriate to discuss power, the use of energy per unit time.

$$P = dE/dt$$

Substituting the energy equation into the power equation gives:

$$\text{PL} = \frac{d}{dt}(\frac{1}{2}mv^2)$$

This simplifies to:

$$\text{PL} = \frac{1}{2}(dm/dt)v^2$$

The mass flow rate $dm/dt$was calculated earlier as

$$dm/dt = (\rho \frac{1}{2}b^2)\text{v}$$

and we can use the final equation of the last section to solve for the speed that the air is thrown down as:

$$\text{v} = 2w/\rho b^2 v$$

Making these substitutions gives the power needed for lift based on known values:

$$\text{PL} = w^2/\rho b^2 v$$

Where P_L is the power needed for lift, W is the weight of the plane, ρ is the density of the air, b is the wingspan, and v is the speed of the airplane. This equation gives us great insight into the fundamental requirements for flight, yet we are still not finished since we must also account for power required to overcome the fluid drag.

Taking the derivative of the total power equation with respect to speed then setting the result equal to zero, we determine the speed for minimum power:

$$v_{min} = \left[\frac{2\,\underline{W}^2}{3\,A\,C\,b^2\,\rho^2} \right]^{1/4}$$

The minimum power can now be determined by substituting this minimum power speed back into our total power equation. Yet when we do this we notice that at this speed the minimum power for lift is ¾ of the total power. Thus we can simplify our minimum power equation to be:

$$P_{T-min} = \frac{4}{3} \left[\frac{\underline{W}^2}{\rho\, b^2 v_{min}} \right]$$

3.2 Design of Model

As per Design requirements we designed in XFLR5 software by giving the requirements like Chord length, sweep angle, root chord, tip chord. Below figure shows the detailed design in XFLR5.

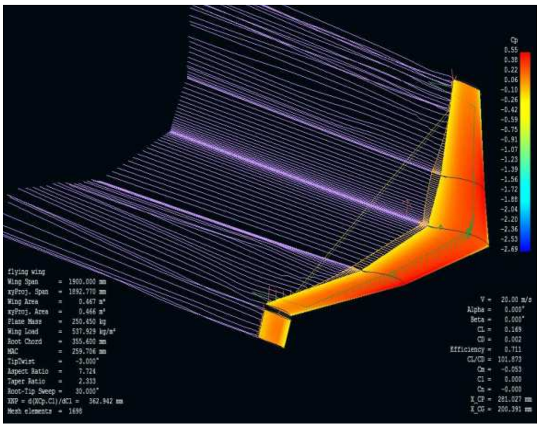

Figure 5: Streamlines Flow

Placing of Masses on the Structural Surface of the Plane such as Motor, Servos, Propeller

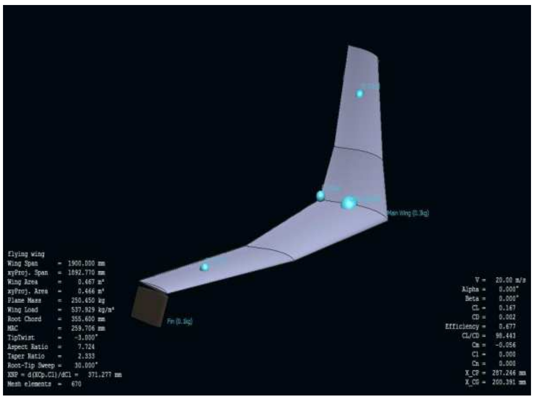

Figure 6: Placing of Masses over the Wing Section

4. FABRICATION PROCDURE AND DESIGN IMPLEMENTATION

Firstly, take the aerofoil MH-60, As it is the best aerofoil for the delta wing or flying wings. Cut the aerofoils of respected of sizes of 14, 10 and 6 inches respectively. To cut the aerofoil. Attach a guitar string to a PVC pipe and pass a current through the battery. The string acts as hot wire. The resistance of wire is 0.5ohms attach an aerofoil to the foam sheet, using the hot wire, cut the foam sheet into aerofoil shape.

Figure 7: Cutting Section of an Airfoil

Similarly cut the aerofoils of 3 different sizes as mentioned. Now join the aerofoils. First make an anhedral angle of 5degrees.Then 5degrees of dihedral. Now cut the aerofoil of NACA0012 for the fins. Stick the fins to the wings.

Figure 8: Placing of an Airfoil

4.1. Procedure for Electronic Parts:

First take a piece foam board and attach to the tip of the root chord for making the motor stiff. Attach the motor to that foam board. As electronic part is the most important aspect in fabrication.

Figure 9: Placing the Propeller

Connect the motor to the ESC. Now place the ESC on the root chord, and stick it with tape. Connect ESC with battery and battery to receiver (channel no3).Make a hole on right and left side of the wing for servos fitting. Fix the servos into that hole and connect to control horns.

Figure 10: Placing of ESC

For flaps keep it as channel 2. and for ailerons keep in channel 1.Set up the sensitivity in the transmitter.

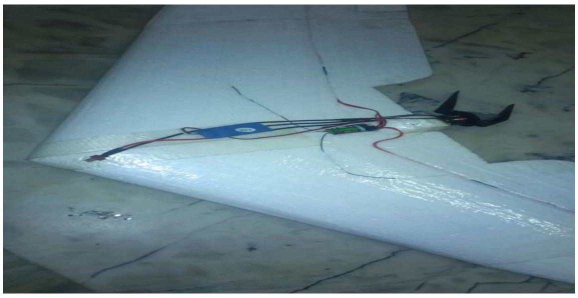

Figure 11: Placing the Battery

To charge the 3S Battery it takes about 45 minutes and the endurance time will be max. 10-15 minutes. In 3S Battery there will be 11 cells up to 9 cells we can charge it gives around 12.4 volts to the motor. For motor it requires 2200 revolutions and 4.7 pitch for rotation. The advantage of these designs is that the body actually acts like a **wing**, adding extra lift. The down side is that flying wings are less stable (they lack a tail), and the rectangular cross-section makes it a lot harder to build a light fuselage that can withstand the rigors of pressurized air flight. The other advantage that a flying wing yields, although this is easier to achieve on paper than in the real world, is efficiency. A flying wing design SHOULD require less thrust for a given speed than a conventional plane design, and should require less fuel for a given speed and distance than a conventional plane design. The main advantages of the flying wing are in field and cruise performances, with take-off and landing field length values analogous to those of much smaller aircraft. The flying wing configuration may better exploit emerging technologies like LFC over a large fraction of the wetted area, composites and aeroelastic tailoring in primary structure, and ultra high bypass ratio engines mounted over the wing..The efficiency is noticeably less than a decent designed plane, never mind a high aspect ratio glider style UAV. The stall characteristics if CG is correct is scary to say the least (Although they are not as bad if the wing is nose heavy).CG is extremely critical making choosing different payloads more of a challenge without serious modification. Launching with pusher flying wings is very dangerous and launching in general is tricky due to their horrible stall characteristics. The yaw stability is horrible compared to a well designed traditional design. Camera stabilization is a must with a flying wing if there is any wind at all.

5. RESULTS AND DISCUSSIONS

The performance of Flying Wings based upon the graphs of static stability and dynamic stability. In static stability we find out the C_m Vs α, C_L Vs α, graphs and in dynamic stability we find out the V(m/s) Vs Time (secs), ϕ(deg) Vs Time(secs) graphs.

Static Stability Graphs

A C_m Vs α graph shows static longitudinal stability. If the gradient of the graph is negative, i.e high on left low on right that represents the positive static stability. If the graph is horizontal it gives neutral stability, positive slope gives negative stability.

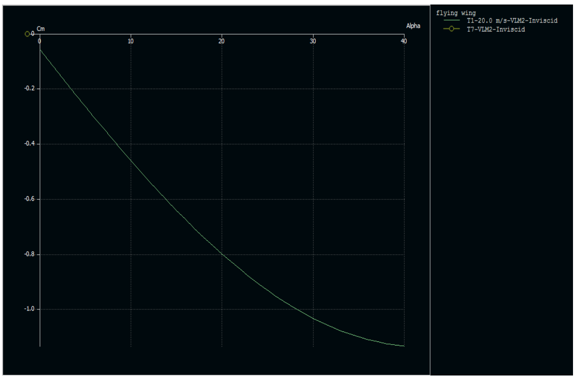

Figure 12: $C_m$vsα Graph

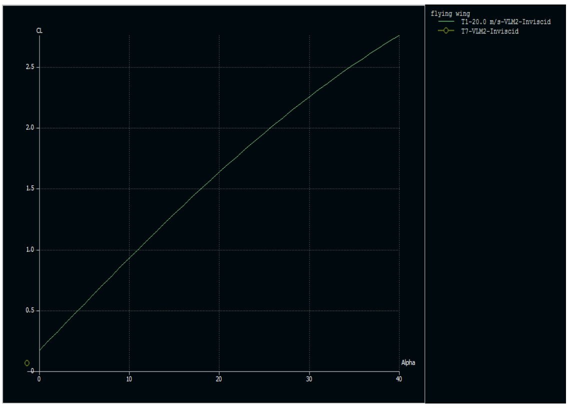

Figure 13: $C_L$vsα Graph

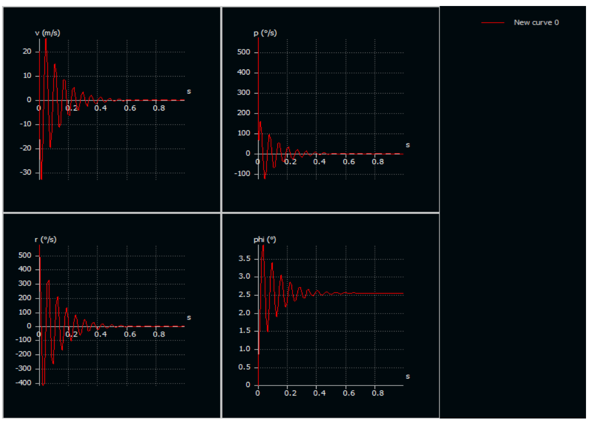

Figure 14: Lateral Direction Stability

CONCLUSIONS

The Computational analysis and structural analysis of the desired model of Unmanned Air Vehicle is examined. The aerodynamic efficiency and the maneuverability with stability and control is performed using XFLR5 and MATLAB. From the results obtained we can conclude that the ideal lift distribution is obtained because of lateral and longitudinal stability properties.

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